GEOMETRY IN ELEMENTARY SCHOOLS

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"It has never been done," was the driver's explanation of the fact that English locomotives were not provided with cabs. The same explanation comes near enough to fitting a good many other situations.

Of all the branches studied in our schools, geometry is the one to which the inductive or experimental method is the most easily and completely applicable. The apparatus and material are simple, inexpensive, everywhere procurable, and always ready for use. The experiments can be performed anywhere, at any time and under any conditions; they can be suspended at any point and resumed at that point whenever it is desired. The results are as certain and as determinable as in any other field. In other words, being equipped with a ruler, a pair of compasses, a pair of scissors, and a supply of unruled paper—light-brown wrapping-paper will answer very well—any boy or girl capable of reading ordinary English and performing the ordinary operations in common fractions can take up the study of geometry and pursue it with unusual mental profit. With this simple outfit and these modest attainments, a pupil can discover for himself all the facts of elementary geometry and obtain a better grasp of those facts than nine out of ten pupils succeed in doing who study the subject in the usual way.

But if this is true, why is not geometry taught in our grammar schools? Why has it not been made a common branch, like arithmetic or geography? "It never has been done," because it never has occurred to our educators that it could be done. Nevertheless, the fact that it can be done is just as obvious as the fact that English locomotives can be provided with cabs.

In a school edition of Euclid, largely in use in many parts of the British Empire, there occurs the recommendation that the

pupils verify all the propositions with ruler and compasses. If the facts can be verified with these instruments, why can they not be discovered with them? They can be. All that is needed is plain directions, and there is no trouble whatever in making these so plain that anyone not absolutely an imbecile can carry them out without difficulty.

Let us take an illustration which will be as clear to the readers who have not studied geometry as to those who have. In the ordinary textbook it is stated that the three angles of a triangle are together equal to two right angles, and a formal demonstration follows. Now, see how easy it is for the pupil to discover this fact for himself, which of course is better for him than to get it as a piece of information.

He draws a triangle. He adjusts his compasses so that the distance between the points will be somewhat less than the length of the shortest side of the triangle. Setting the steel point upon one of the corners of the triangle he describes a curve between the sides that form that corner. He repeats with each of the other corners. On another part of the sheet he describes a circle, and from any point on its circumference lays or spaces off the three curves one after the other. He finds that they extend half way around the circle. He has already learned (by experiment) that half a circumference measures two right angles. He repeats the foregoing operations with the different kinds of triangles, equilateral, isosceles, etc., and the result is always the same —the curves described between the sides always extend half way around the circle, no more and no less. If occasionally there is a small variation, he at once suspects it is due to his not having taken sufficient care in making his measurements. By the time he has concluded his experiments, it is not necessary to tell him that the three angles of any triangle are together equal to two right angles. He has found out the fact, and therefore he *knows* it.

"But," it may be objected, "he doesn't know *why* the three angles are equal to two right angles." No, he does not, and in this life he never will. We don't know the "why" of a single one of the facts of geometry. Admirers of the deductive

method of reasoning (which far be it from my intention to disparage) seem to think that it is the only method by which we can become convinced of what they sometimes style, "the eternal verities." They seem to think that no one can be sure that the three angles of a triangle are together equal to two right angles until he has learned to demonstrate the proposition in the usual way. They seem to think that, however many triangles he may test with the compasses, he never can be certain that there cannot be constructed a triangle to which the test will not apply. Very well, then, let him set his doubts at rest by learning the deductive demonstration. The point I wish to make is this: It is far better for a boy to discover a fact by experiment first and to reason it out afterward, than to be furnished with the fact and a formal demonstration thereof, with seldom or never the suggestion that he verify by experiment. That is the way boys and girls are taught geometry today; that is the way they have been taught it ever since Euclid's time, and it is exactly the reverse of the right way.

Let us consider some of the results of this Chinese way of teaching. At least five-sixths of our school children never get the opportunity to study geometry, or, at best, any more than the meager amount in the ordinary arithmetic. The study has to be postponed until the high-school course is begun, and the vast majority of our children do not attend the high school. It is true that in the grammar schools of some cities a smattering of geometry is given, but scarcely enough to be of any consequence. Practically at least five out of six of our school children are debarred from studying the subject.

But don't they have enough to do at present in the lower grades, without trying to crowd in geometry? They may have enough to do, but a great deal of it is of far less educational value than geometry, and some of it of no value at all. Instead of promoting, some of it actually retards, intellectual development.

It is impossible, of course, to go into details with regard to what is taught in our schools. It suffices to assert, without fear of disproof, that nothing taught therein is of greater educational value than the rational study of geometry would be. The

facts of geometry are as important as any to which the pupil's attention can be directed, and the mental discipline obtained by getting hold of those facts in the right way is exactly the kind that will enable him to deal with the problems that will confront him after he leaves school. A little less "analyzing and parsing," a little less memorizing of descriptive geography and the battles and sieges in history, a little less oral speling, etc., would give time enough for geometry in the grammar school.

Another result of the Chinese method is, that the comparatively few who get the opportunity to study geometry fail to get a good knowledge of the subject. To appreciate deductive reasoning, the mind must have attained a degree of maturity that is rare in the case of even high-school pupils. The average student of geometry, in both recitations and examinations, relies upon memory more than upon his power to reason. No instructor will dispute this contention. In pursuing the inductive method, the faculty of memory cannot enable the pupil to appear to have a knowledge that he does not possess. He is put to precisely the same kind of test that a man pretending to know how to set type would be put to in a printing office. He either can or cannot do the thing required. If he cannot, the possession of the most prodigious memory would not enable him to make the slightest concealment of his inability.

In probably every high school and college in the country, instructors in mathematics accept every day recitations that they very well know are unsound; that is, they know that the pupil doesn't fully understand what he is talking about, and that a little close questioning would make the fact too obvious to be overlooked. But what can they do? There are pupils who may be good in everything else, and perhaps brilliant in some particular subject, but who cannot get hold of mathematics. It seems hard that they should not be allowed to graduate with the others. So far as geometry is concerned, there is no reason why anyone cannot learn it, or enough of it to pass any fair examination.

Excluding idiots and imbeciles, was there ever a boy so stupid that he could not learn how to do farm work, or a girl so stupid

that she could not learn to do housework? How is such work learned? Simply by doing it. We don't give a boy a book containing disquisitions upon farming tools. We give him a hoe and set him to hoeing. However awkward he may be at first, sooner or later he becomes able to accomplish something.

In all my experience, I never have found a boy or girl so stupid as not to be able to learn how to use a ruler and compasses and to make discoveries by using them. More than this, I never have found a boy or girl who did not immediately become interested in this kind of work and inclined to keep on with it. I have had one opportunity to try this method in the schoolroom, that is, to give it a full and fair test. That was in a mixed school in a southern state. The pupils, with a single exception, were very backward. All of them who could do fractions, and some who could not, were formed into a geometry class. In four months' time this class had covered all of plane geometry and had made a beginning in solid geometry. The close of the school year prevented the test being carried any further and the opportunity to repeat it has not occurred. Several pupils who had been left out of the class because I supposed them to be too young to derive any benefit from the exercises, after watching the others for a few days, teased to be allowed to join. They remained until the end of the term, and one of them became unusually proficient in the work.

The recitations took place the last thing in the afternoon—that is, at a time when children are likely to be thinking more about getting away than anything else. It was a common occurrence however, for the recitation to be prolonged beyond the hour of closing. Anyone who wished was at liberty to leave at this time, but no one ever availed himself of the privilege. On several occasions I had to insist that the investigation under way be postponed until next day.

I do not allege that all these children mastered the elements of plane geometry, but many of them acquired a fair knowledge of the subject, and every one of them obtained much more than a smattering.

Unfortunately, no one in the place was capable of appreciating the significance of the result of this test—a result that far surpassed my expectations. It convinced me that there is no good reason why all our school children should not learn elementary geometry. It is simply a case of "it never has been done."